THE TECH ENGINEERING NEWS

APRIL, 1933 VOLUME XIV, NO. 3
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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THE TECH ENGINEERING NEWS

APRIL, 1933
VOLUME XIV
NUMBER 3

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME XIV APRIL, 1933 NUMBER 3

A Survey of MODERN AUTOMOBILE DESIGN *—Developments and Trends*

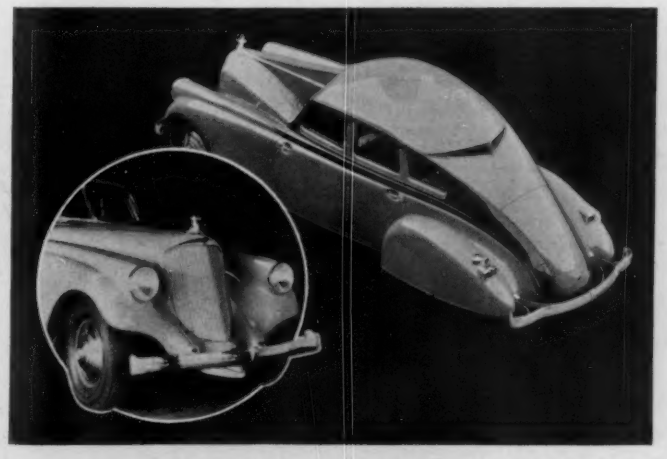
By DEAN A. FALES '15

Associate Professor of Automotive Engineering
Massachusetts Institute of Technology

THE 1933 automobile models have now become familiar to the public. The outstanding developments have been in style, increased performance, and easier operation.

The style set by Graham last year met with popular approval and has been adopted in some part by most of the American manufacturers. Many automobiles are now so low that vision is restricted, and the process of getting in and out of a car has become a series of awkward contortions. The ground clearance has been decreased to a point where steep sidewalk and garage ramps, exceptionally bad roads and detours often prevent the passage of a car. It would seem that the lowness so desired for style has about reached its practical limit, if it has not gone beyond. The width of the car has increased to accommodate tires with greater cross-sections and at the same time provide a rear seat that will hold three passengers. The width of some cars is now greater than their height. The rounding off of corners and edges has reduced vision by lowering the tops of windows. America is mass-minded, and if the present style is acceptable, the inconvenience will be borne as a self-imposed penalty that must go with "smartness."

With the exception of possibly two models, every American car is capable of speeds in excess of seventy-five miles an hour. Acceleration has been increased by added power, decreased weight, and easier gear changing. Today the modestly priced popular cars give performances that could not be equalled by the most expensive passenger cars of only five years ago. It seems that the next step is to design the automobiles so that their high speeds can be enjoyed with greater safety, and their control can be more exact.



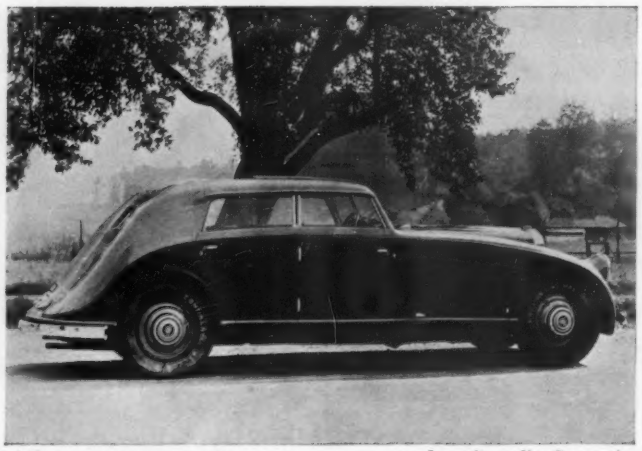
An extreme product of the present-day trend in streamlining. *Machine Design*

Many gadgets have been developed to eliminate some of the many actions needed to start and operate an automobile. Some of these will be of temporary use and some will survive. Automatic clutches, free wheeling, automatic chokes and mixture regulators, and automatic starters are a few of the recent additions. Steering has been developed so that only a light effort is needed for guiding a car in motion. The automatic clutch, which may be operated by vacuum or by centrifugal force, has eased an arduous task. The multiplication of pedal effort by means of vacuum or by a mechanical servo-motor has made stopping a car no more of an effort than pressing the accelerator pedal. Actions that formerly required pounds of effort are now accomplished with the greatest ease.

In spite of the times, economy of operation is second to performance. The car that leads the race from the green traffic light is more desired than one that can go the greatest distance on a given amount of fuel.

To anticipate what we may expect in the future we must consider what we can improve today. What the style of the future will be can only be determined by what the buying public thinks it wants.

Mechanically, many improvements are needed. When they can be produced commercially they will add to the safety and pleasure of operation. Kick shackles are used on a great many automobiles. These shackles permit the front spring on the steering side to move within limits in relation to the frame, since neither end of the spring is attached directly to the frame. The duty of the kick shackle is to take the "snatch" out of the steering wheel when the car hits a bad bump. In operation the action is such



A European expression of streamlining. *Jaray Streamline Corporation*

that the axle on the operator's side of the car can move out of its normal position in relation to the rest of the car. When this happens a certain amount of steering is accomplished. At low speeds the operator naturally corrects for this turning with the steering wheel. At high speeds the human part of the equation cannot keep pace, and the car may have drifted several feet toward the center of the road before the operator has it under control. The remedy, it would seem, would be to copy some of the European designs where both front springs are shackled at each end, and where the axle position is maintained by radius rods. In some cases these radius rods relieve the springs of the braking torque which adds to riding comfort and makes braking better. One of the outstanding features of the Ford is the "wishbone" construction, which is a form of radius rod.

The present types of spring suspensions with their controlling devices have been developed to a point where not much more can be expected from them. Again we may turn to Europe and try some of the many independently sprung wheel installations that are in successful operation there. Every year an increasing number of European cars adopt this type of suspension. In the majority of cases the rear axle remains as it now is, but the front axle is eliminated and each front wheel has its own spring suspension to the frame. In a few cases the front axle remains as it now is, and each rear wheel has its own spring suspension to the frame; in this type the drive to the wheels is through separate drive shafts from a differential mounted on the frame. In some cases all four wheels are independently mounted, and there are no axles. By the use of independent wheel mounting the unsprung weight of the vehicles is reduced. Springs other than the conventional leaf springs can be used, such as coil springs and rubber springs, which are exempt from the limitation in periods of vibration that leaf springs have. The independently sprung wheels give better riding and road-holding qualities, can give better steering, and can be more suitably designed to care for braking and driving torques than the conventional American spring suspensions.

In order to lighten the weight of the unsprung rear axle we may see the old De Dion idea of placing the differential on the frame and driving the rear wheels through separate drive shafts revived.

Brakes must be improved to care for high speed operation; here a balance between weight and effectiveness must be made. In a large car each brake may be called upon to absorb over a hundred horsepower in performing its work, and the amount of heat generated by the friction must not be allowed to affect the brake adversely.

Possibly the most eagerly awaited development is the infinitely variable gear ratio and automatically operated transmission. The old Orient Buckboard and the Carter car had friction transmissions with an infinite number of gear ratios. The Owen Magnetic, "the car with a thousand speeds," had a flexible electric transmission. Experiments with hydraulic devices have been performed. Many busses use electric transmissions. When a suitable commercial unit is developed, acceleration, flexibility, hill climbing, speed and economy will all be available to a heretofore undreamed-of degree. The vehicle and engine can have the most suitable driving ratio for any conditions, and it will change as needed. Such a transmission will be of great benefit to the engine as the vehicle flexibility will come from the transmission and not from the engine as it does at present. In many of our present cars the engines can turn as high as five thousand revolutions a minute, but the oil control problems at the higher speeds are more difficult to solve. The use of an automatic transmission with an infinitely variable gear ratio will allow the use of an engine of moderate speed and excellent torque characteristics.

The low pressure tires of large cross-section that have been installed as replacement equipment by some owners have not been favored by many engineers. To have these large tires operate satisfactorily would mean the redesigning of a number of car parts, and in the larger cars it would mean the addition of power steering. However, if the buying public wants these tires the manufacturers will see that cars with them are available.

The front drive car seems to appeal to only a limited number of motorists, and it is not expected to gain in popular favor. The added noise of having all the machinery in front of the passengers seems to more than offset some of its excellent features.

The streamlined car with engine mounted in the rear that was hailed with such enthusiasm last year when it was brought over from England has lost some of its appeal to the engineer. Its streamlining permitted its eighty horsepower engine to drive it at a higher speed than many of our conventional cars with well over one hundred horsepower could attain. Its length and appearance might have caused sales resistance, but the biggest drawback was its lack of acceleration. Americans want to get started quickly and for that, low weight and high power are required. If the car can get under way quickly, it will have enough power to be driven at a

(*Continued on page 57*)

Sketch of a proposed Italian rear-drive car. *Automotive Industries*

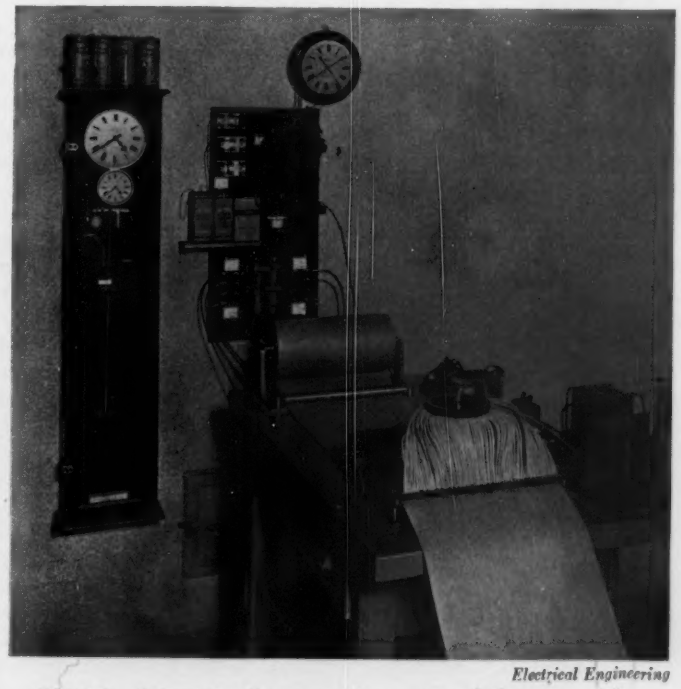
"What Time Is It?"

Civilization Asks the Question — Science Must Supply the Answer

By MILTON B. DOBRIN '36

"WHAT time is it?" is one of the most common questions asked in any language on earth, for today, more than ever before, our lives are ruled by the clock. In our modern complex industrial and economic civilization, time is money; our great arteries of transportation are regulated fundamentally upon a temporal basis; the strict observance of the exact time is even more important in the organization of our latest regular channel of communication, the radio; and in our institutions of science, great precision of time is often necessary for the precision of measurements. Uniformity of time the world over has become a prerequisite for the orderly operation of commerce and production, and to achieve this uniformity a complicated but highly efficient system of distribution has been put into operation.

Since the beginning of civilization, man has endeavored to measure the passage of time by reference to the rising and the setting of the sun. The ancient Chaldeans, for instance, measured their time by counting the number of pails of water that would flow from a tank between sunrise and sunset. But it was not long before these early philosophers discovered that the length of time between sunrise and sunset is not constant; and since then the rotation of the earth with respect to the fixed stars has been the basis for the recording of time.



Electrical Engineering

Electric chronograph comparing rates of three precision clocks, one of which is seen at left.

Tradition has it that Pope Silvester II (999 A.D.) invented the first clock. An early mechanical timekeeper was installed in a Westminster tower in 1288; another in Canterbury Cathedral in 1292. A clock which had been placed in Dover Castle in 1348 was put on display, still running, at the Scientific Exhibition of 1876. All of these pioneering attempts to measure time mechanically lacked even moderate accuracy and were corrected usually by sundials, infrequently by rough stellar observations. The year 1675 saw the founding of Greenwich Observatory, the meridian of which has been until the present day the standard from which longitude and time zones are measured.

In nineteenth century America, every community maintained its own solar time as determined by its longitude. Until the railroad became a common means of transportation, little confusion was caused by this lack of uniformity. But when each of the various railroad lines ran all of its trains on separate standards of time, passengers too often missed their trains. To remedy this situation, a Scotch Canadian named Sanford Fleming proposed that the world be divided into twenty-four time zones, each extending for fifteen degrees in longitude and each maintaining time one hour apart. The American railroads, conferring in 1883, decided to divide the time of North America according to Fleming's plan and to run their trains uniformly. The next year Congress legally established Eastern, Central, Mountain, and Pacific standard time zones across the United States.

The time kept by each standard zone of the world has been arbitrarily based on that of Greenwich, which is five hours ahead of Eastern Standard Time. The standard for time in the United States is the indication of the six precision clocks kept in the basement of the Naval Observatory on the outskirts of Washington. These are sealed inside of air-tight cases in the observatory's clock-vault, a square chamber with thermostatically controlled temperature, and are checked almost nightly with the true time as measured by the mean rotation of the earth. These determinations are made through small telescopes known as transit circles, which point exactly north and south along the meridian. The astronomer notes through the transit circle the crossing of this meridian by a star. Just when a "clock star" will cross the meridian is calculated to within a few thousandths of a second, and a list of several hundred such stars, most of which cross the meridian of Washington at the zenith, is kept on hand.

The process of checking the standard clocks consists chiefly of ascertaining the difference between the true time determined by the transit circle and the time indicated by the clock. Any discrepancies are indicated by the chronograph — a calibrated cylinder which revolves at a rate controlled by the movement of the clock, and upon which a penpoint inscribes a spiral line. Any point on the line represents an instant of time. Another pen, just above the cylinder, is connected with a micrometer apparatus operated by the observer. As the star passes each of twenty points across the field of vision of the telescope, the apparatus causes interruptions in an electric circuit which record each event on the cylinder. The mean time represented by the twenty marks along the spiral line is computed and compared with the time the observed star should theoretically have crossed the meridian. The difference is the error of the standard sidereal clock; and before time signals are given out, the error is corrected by delicate adjustment of the pendulum.

(*Continued on page 57*)

Beer:

An Object Lesson in Applied Chemistry

By JAMES DONOVAN '28
Chemical Engineer, Acme Industrial Equipment Company

BEER is a food beverage, a cereal drink, the saviour of the American nation — or the debasing drink of other days. Beer will give employment to thousands — and throw other thousands out of work. Beer will break the back of the depression — if enough invest in it and enough others imbibe it. Practically everyone is hearing, reading, talking about beer. Some are interested in its chemistry, some in its manufacture, others in its social and economic effects.

Neglecting these last absorbing and controversial topics and considering only the chemistry and manufacture of beer permits a brief, elementary discussion which, although somewhat inaccurate because of neglect of details, may give a general picture.

The Chemistry of Beer Making. Beer making is an art. It was practiced long before the advent of modern science and, although science can explain it in simple terms, the wide diversity of individual tastes and the existence of many variables in the process necessitates the retention of a "Braumeister," who makes allowances for the variables and by constant attention produces a standard product. Efforts are being made to apply process control to all brewing operations and thus assure uniform products, but at the present time the "Braumeister" is indispensable.

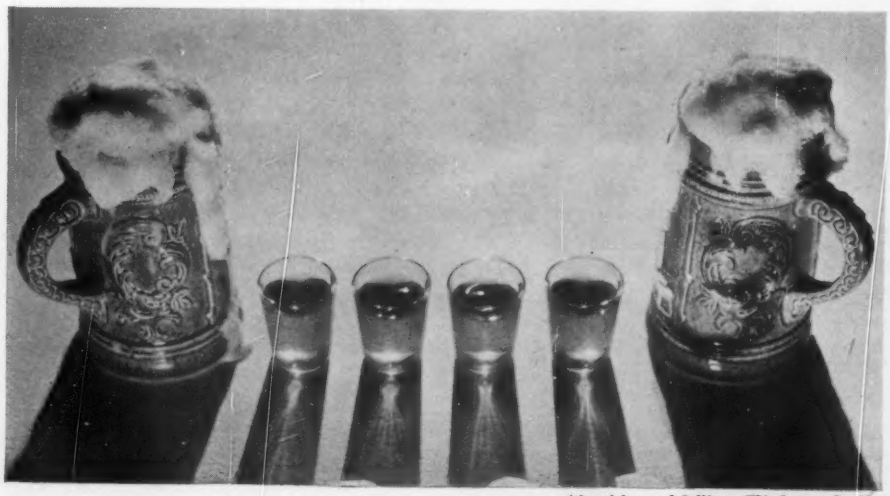
The basic chemistry of beer manufacture is well known to be the changing of starch to sugar, and the fermentation of the sugar by yeast to yield alcohol. The presence of certain albuminous substances is largely responsible for the much prized foam or "head." The general balancing of the operations as regards the quantities of sugar, starch, hop extract, etc., gives rise to the palate sensations of "fullness," "sharpness," and "bitterness."

Starch exists in barley in an insoluble form and is first rendered soluble by malting. In this process the barley is subjected to soaking and to the action of air, thus allowing germination. This lasts for several days until the acrospire or sprout has reached about three-fourths the length of the grain. It is then "kilned," that is, heated to stop the growth and also to give a certain cooked flavor which affects the palatableness of the beer, or, at times, to give color to the product. Some starch is obtained from rice, which is used especially in the brewing of pale ales.

In the brewery the starch is extracted from the malt by warm or hot water, using various processes and temperatures, depending upon whether a "lager beer" or an "ale" is desired. The German system, sometimes called the "decoction system," which is used to produce lager beers, gives rise to a "fuller" beer, with more malt extract and less alcohol than the English ale. Lager beer is normally between 2.5 per cent and 3.5 per cent alcohol by weight, while ale is nearer 5 per cent alcohol. These differences in alcoholic content are largely accounted for by the method of "mashing," the name given to the extraction process. In general, a low temperature extract of 150°–160° F. has more diastase, the enzyme that changes the starch in the malt into a sugar. Hence more alcohol will be formed during the subsequent fermentation than would be if the formation of the diastase and hence of the sugar were inhibited. This latter is accomplished by a high temperature, as diastase loses its effectiveness at elevated temperatures, and if a portion of the mash is quickly heated to 212° F., more starch is obtained with less sugar. When fermented, this gives a "full" tasting lager beer rather than the tang of ale.

Since the fermentation to yield alcohol requires the presence of dextrose and certain mineral matter, it is now common practice to add corn sugar, usually as a syrup, to the "wort," or unfermented malt extract. It is thus possible to reduce the quantity of malt required. The malt is then handled so as to produce less sugar and by proper balancing a satisfactory beer is produced. In this case the malt largely supplies the body and flavor of the beer.

After separating the spent grains, the extract is sent to the "coppers." These are large copper kettles in which the extract is boiled, partly to concentrate it and partly to extract the hops added at this stage. These hops are the flower of the hop plant, and contain resins and bitter matter which, when extracted, give the highly prized bitter taste to beer and impart some preservative value. At the same time certain albuminous matters in the extract are precipitated and form flocks which are readily separated. The product from the coppers, now called "hot wort," is separated from the hops and chilled to about 40° F. in the case of lager beers and 60° F. in the case of ales. During the chilling process further precipitation of the matter which has coagulated and become insoluble in the coppers takes place.



Advertising and Selling—Windmann Studios

Fermentation is brought about by yeast, of which there are many kinds — some yielding acids such as vinegar, others producing alcohol, while still others cause putrification. Only a few kinds of yeast, one of which goes by the cryptic name of Sacch. Cerevisiœ, are satisfactory for brewery use. The others, if they

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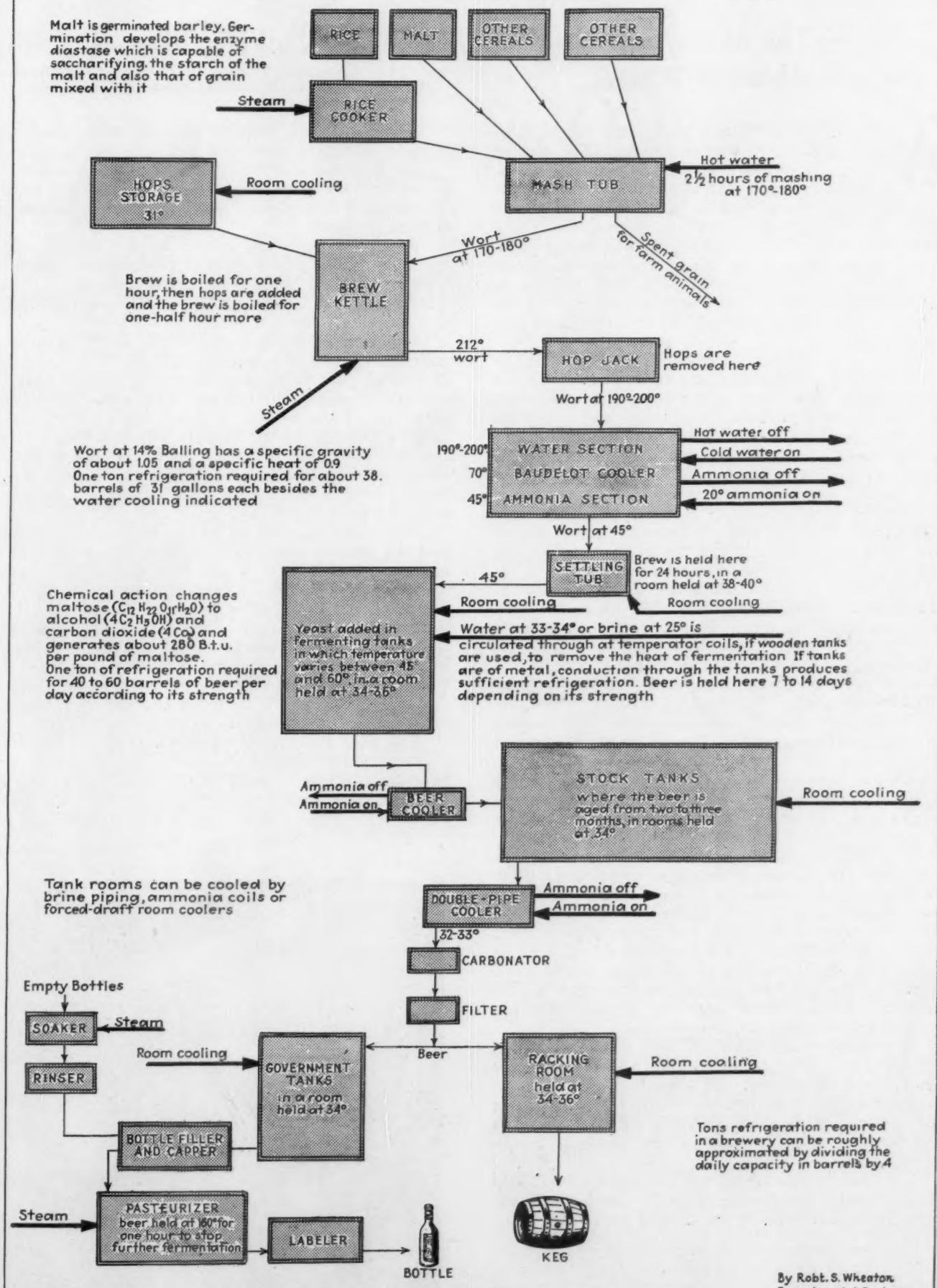
Malt is germinated barley. Germination develops the enzyme diastase which is capable of saccharifying the starch of the malt and also that of grain mixed with it
RICE
MALT
OTHER CEREALS
OTHER CEREALS
Steam
RICE COOKER
HOPS STORAGE 31°
Room cooling
MASH TUB
Hot water
2½ hours of mashing at 170°-180°
Wort at 170-180°
Spent grain for farm animals
Brew is boiled for one hour, then hops are added and the brew is boiled for one-half hour more
BREW KETTLE
212° wort
HOP JACK
Hops are removed here
Steam
Wort at 190°-200°
Wort at 14% Balling has a specific gravity of about 1.05 and a specific heat of 0.9
One ton refrigeration required for about 38 barrels of 31 gallons each besides the water cooling indicated
190°-200°
WATER SECTION
Hot water off
Cold water on
70°
BAUDELOT COOLER
Ammonia off
45°
AMMONIA SECTION
20° ammonia on
Wort at 45°
SETTLING TUB
Brew is held here for 24 hours, in a room held at 38-40°
45°
Room cooling
Room cooling
Water at 33-34° or brine at 25° is circulated through at temperator coils, if wooden tanks are used, to remove the heat of fermentation If tanks are of metal, conduction through the tanks produces sufficient refrigeration. Beer is held here 7 to 14 days depending on its strength
Chemical action changes maltose ($C_{12}H_{22}O_{11}H_2O$) to alcohol ($4C_2H_5OH$) and carbon dioxide ($4CO_2$) and generates about 280 B.t.u. per pound of maltose.
One ton of refrigeration required for 40 to 60 barrels of beer per day according to its strength
Yeast added in fermenting tanks in which temperature varies between 45° and 60°, in a room held at 34-36°
Ammonia off
Ammonia on
BEER COOLER
STOCK TANKS where the beer is aged from two to three months, in rooms held at 34°
Room cooling
Tank rooms can be cooled by brine piping, ammonia coils or forced-draft room coolers
DOUBLE-PIPE COOLER
Ammonia off
Ammonia on
32-33°
CARBONATOR
FILTER
Empty Bottles
SOAKER
Steam
RINSER
Room cooling
GOVERNMENT TANKS in a room held at 34°
Beer
RACKING ROOM held at 34-36°
Room cooling
BOTTLE FILLER AND CAPPER
Tons refrigeration required in a brewery can be roughly approximated by dividing the daily capacity in barrels by 4
Steam
PASTEURIZER beer held at 160° for one hour to stop further fermentation
LABELER
BOTTLE
KEG

REFRIGERATION AND OTHER POWER SERVICES REQUIRED BY A BREWERY

By Robt. S. Wheaton, Experimental Engineer, Vilter Mfg. Co.

Power

From Grit to Grindstone

—*The Manufacture of Abrasive Wheels*

By CHARLES L. NORTON, Jr. '25
Instructor, Division of Industrial Coöperation
Massachusetts Institute of Technology

ABRASIVES have been used since the time of early man in one way or another. The need of fashioning articles from hard materials by means of abrading them with materials of greater hardness has always been present. Up until fairly recent times the main abrasive used was quartz, which is a crystalline form of silica. This quartz is contained in sandstone and was used for grindstones and whetstones. The small grains of quartz are cemented together in the sandstone by films of silica or other material to form a mass which can be quarried out and fashioned into abrasive articles.

Quartz is not the hardest mineral, and consequently when deposits of corundum and emery were available commercially, they were used extensively on account of their superior hardness. Corundum and emery do not occur in such a way that they may be cut out and shaped directly. The emery or corundum grains are separated from the surrounding material and then crushed and screened to definite sizes. The grains are then mixed with some clay material and fired in a pottery kiln. The clay hardens under the action of heat and holds the grains in much the same way that the quartz grains are held in the sandstone.

The purity of the natural abrasives is not constant, so that abrasive articles made for some specific purpose could not always be duplicated. This led to the introduction of two important artificial abrasives, both of which are products of the electric furnace. The first of these is crystalline aluminum oxide, and is actually artificial corundum. This material is made from bauxite, which is hydrated aluminum oxide. The second material is silicon carbide. Two of its more common trade names are "carborundum" and "crystolon." Crystals of silicon carbide are rare in nature and this material is essentially an artificial mineral whose primary use is in modern abrasive articles. Silicon carbide is made in the electric furnace by heating a mixture of silica sand and coke. Sawdust is added to the charge to render it porous and allow the escape of gases. The aluminum oxide abrasive is more efficient when used on materials such as steel, which have a high tensile strength, whereas the silicon carbide abrasive is more effective on materials of low tensile strength, such as cast iron. These artificial abrasives are made under close manufacturing control and their quality is very uniform. After removal from the furnace they are crushed and screened into separate sizes.

It is possible that other artificial abrasives may be developed which will supersede the two which are now used almost exclusively. An abrasive which could be manufactured in a continuous process at temperatures commercially attainable with gas or oil would have an advantage over the electric furnace products in the matter of cost.

The quality and amount of bonding material used in the abrasive article determines its "grade" or hardness. Several different types of bond are used.

Silicate of soda, bakelite or some other synthetic resin, or shellac is sometimes used as a bond in certain types of abrasive wheels. The bonding material is mixed with the abrasive grains and shaped in a mold. The wheel is then given a heat treatment to harden or mature the bond.

Another type is the rubber bond. The abrasive grains are rolled into a sheet of crude rubber which is later vulcanized by heating under pressure. These wheels are very tough and are used when the wheel must be very thin.

The vitrified bond is one of the most commonly used and consists of a ceramic mixture. It may consist of a single low firing clay, but it is more usually a mixture of clays and feldspar with some additional materials. These ceramic mixtures are usually closely guarded formulas by the abrasive wheel manufacturers, but it is a fact that wheels made in the laboratory at Massachusetts Institute of Technology which were bonded with a single clay were as efficient as commercial wheels of the same grade and grit.

The wheel is made by mixing the abrasive grains and the ceramic bond with sufficient water to form a creamy mass. This is poured into special molds and allowed to dry in the air until firm enough to handle, when it is put into a drier and dried thoroughly. The wheel is then placed on a horizontal rotating table and is shaved approximately to shape, and a hole is bored in the center. The periphery of the wheel is trued so that it is concentric with the center hole. Sufficient material must be left after the shaving operation to allow for the subsequent shrinking during firing.

The dried and shaped wheel is next placed in a fireclay container called a "sagger" and is completely embedded in quartz sand. This method of setting is similar to that used in the firing of pottery. The sand supports the wheel and prevents it from deforming dur-

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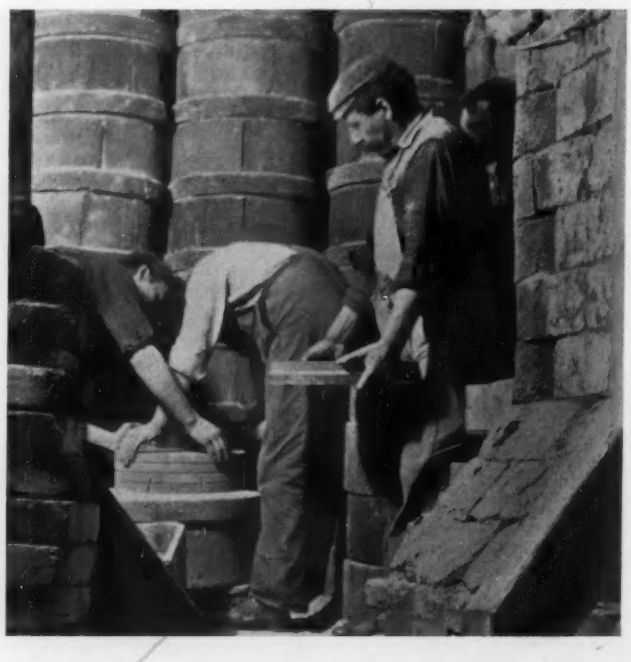

Abrasive wheels being piled in a kiln, where they will be fired.

Stained Glass Windows

—*Modern Work In a Medieval Art*

By WILBUR H. BURNHAM

A STAINED GLASS window is composed of small pieces of white and colored glass held firmly together by strips of grooved lead soldered at the joints. It must be clearly understood that the color, the real glory of stained glass, is not painted on the glass, but is produced when the glass is manufactured. Various metallic oxides mixed with the glass while it is in a molten state produce the coloring. It can be readily seen that whenever a change in color is desired in a window, a separate piece of glass must be cut. With a few exceptions, the color pervades the whole piece of glass, and its unequal thickness gives the variations in shading. "Flashed" glass is white glass covered with a layer of colored glass. Beautiful effects can be obtained by eating away parts of the colored glass with hydrofluoric acid. The only paint used in the making of a window is an opaque, vitrifiable pigment, used merely to delineate form and detail. No actual color is ever painted on the glass, except a "stain," an oxide of silver. White glass, with the use of this stain, produces a beautiful transparent yellow, varying in the tint from a light lemon yellow to a rich orange, after it has been fired in a kiln.

Although modern manufacturing assists the present-day craftsmen, the same processes are employed as in the Middle Ages. In place of moulding the lead by hand, the modern workers buy it all manufactured in strips of various sizes and shapes. Gas and electricity now take the place of charcoal for heating the soldering irons, while the diamond or steel wheel is used to cut the glass in place of the primitive method of drawing a red hot iron across the glass, and with sufficient hand pressure breaking the glass in two.

Like other technical arts, the conception and development of stained glass necessitate the employment of trained craftsmen. As in the medieval days, the window designer should be a thorough craftsman, capable of not only designing, but painting on the glass and if necessary, leading the window.

When a glass designer and craftsman is commissioned to make a window, he should first of all, whenever possible, see the building his window is to adorn and study very carefully its lighting conditions and architectural surrounding. Too many of our churches have already been filled with windows in which styles and periods have been sadly mixed. Now, thanks to many of our architects, even the so-called commercial glass men must keep within certain limitations.

The preliminary design in water color, drawn to scale, serves as a working model for the artist and gives to the client an idea of the appearance of the completed window. After the design has been approved, the next step is to draw the "cartoon," or full-sized drawing in black and white. This drawing is the actual size of the completed window and all details, including lead lines, Tee bars, and saddle bars (of which mention will be made later) are carefully drawn. The cut-line drawing and pattern drawing are traced from the cartoon. These drawings show very clearly the various shapes and sizes of the glass, and to offset any future difficulties, the shapes are numbered.

The pattern drawing is cut into the individual patterns for the glass with a double-bladed knife. This knife cuts out a thin strip of paper from between each pattern, which allows for the heart of the lead to fit between each piece of glass. The patterns are placed upon the cut-line drawing, and with the water color design as a guide, the colors are selected and with a diamond or steel wheel, the glass is cut around the patterns.

Then the artist places the pieces of glass upon the cartoon and traces all drawing lines and details on the glass with the vitrifiable pigment mentioned before. For tracing, varnish and turpentine are usually mixed with the pigment, although certain workers prefer mixing water with the color, which is either brown or black. To prevent any possibility of losing the trace lines in the next process the glass should be fired until the painted lines actually become a part of the glass. For the ensuing process of painting, it is necessary to set the glass in place before a window. A large plate glass easel is therefore placed on a flat bench, with the cut-line drawing placed beneath to aid in locating the pieces of glass. A small space must separate the pieces of glass, for later on the heart of the lead fills this space. Melted wax is dropped into these spaces at intervals, holding the glass firmly to the easel. By placing the easel in an upright position before a window, the glass is seen as a whole for the first time, and any color changes decided are made. Since in the finished window, black lead lines will take the place of the brilliant light now visible between the pieces of glass, spaces are filled in with black paint (or should be by any craftsman who is sincere in his effort to reproduce his design accurately).

Each piece of glass is then covered with a mat of the same pigment used in tracing, with gum arabic as the adhesive medium and water to thin the color. When the paint is dry, lights are taken out with a bristle brush or with the finger and palm of the hand, leaving only enough paint to give to the glass an interesting texture, and which if well done, will mellow the color of the glass without causing loss of any of its particular gem-like brilliance. The painter must take into consideration the distance from which the window will be seen and gauge the texture accordingly. Light plays many tricks when shining through glass. For example, a clerestory window must be painted boldly, with the use of heavy trace lines, in order to get a result that is strong in design.

With the painting completed, the pieces of glass are removed from the easel and fired so that the paint becomes a part of the glass permanently. Again the glass must be waxed upon the easel and painted for the second time, for the intense heat in the kiln has probably reduced the paint and in some cases burned it almost entirely away. Even a third painting is not infrequent, and a special firing for stain gives the most satisfactory results.

The glass is now ready to be put together with strips of flexible lead the shape of an "H." The cut-line drawing is laid on the glazing bench; a straight edge of wood is nailed to the base and another along the side of the drawing. Long strips of wide lead are placed against

(*Continued on page 59*)

The Application of PHOTO-ELASTIC ANALYSIS *to Stress Problems*

By *MIETH MAESER*

Instructor, Mechanical Engineering Department
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Editor's Note: Photo-elasticity as a method for the determination of stresses has been known and used for some years. Photo-elastic equipment was introduced at the Massachusetts Institute of Technology in 1922, the Institute thus becoming the first educational institution to possess such apparatus. It is believed that a complete explanation of the method has never before been printed.

IT will be the purpose of this paper to present the mechanics and physics of photo-elasticity in as simple a manner as possible. Diagrams will be used wherever possible to illustrate the principle involved.

Photo-elasticity is one of the several "model" methods used to determine the state of stress in structures which are impossible of solution by mathematical means.

Space will not permit giving the history of photo-elasticity nor a summary of the various problems to which it has been applied with varying degrees of success. The article will be limited to a statement of the principles involved in the method and the presentation of a simple problem to illustrate its application and accuracy.

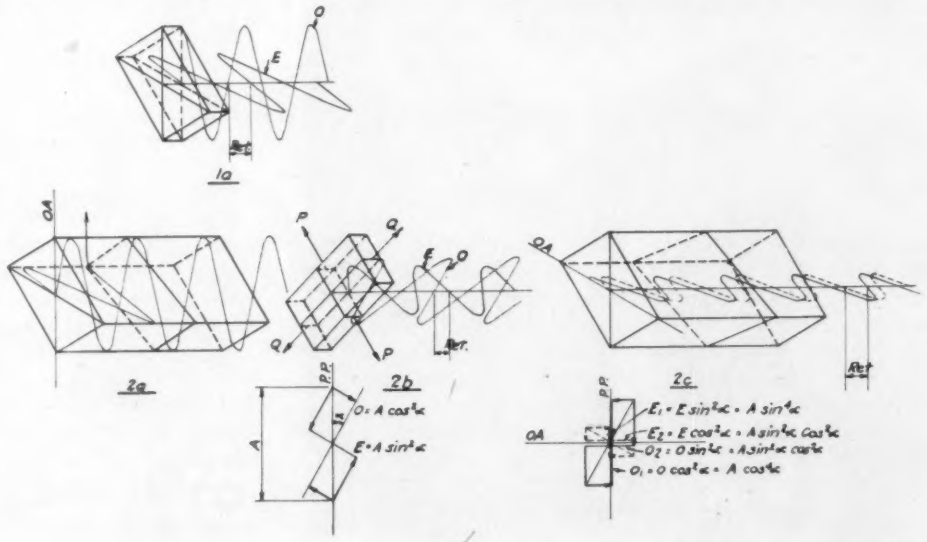
Mechanics. At any point in a body subjected to plane stress there are two planes at right angles, upon which the stresses are purely normal; that is, planes upon which no shearing stresses are acting. These planes are called principal planes. The stresses acting on these planes are designated as principal stresses. To determine the state of stress at any point in such a body it is sufficient to determine the direction and the magnitude of the principal stresses at that point. The proof of this proposition can be found in any book on the theory of elasticity.

Double Refraction. There are several transparent materials such as quartz, mica, and calcite which are by nature double refracting. When a beam of light from any source passes through a prism of one of these materials the light upon emergence is polarized, *i.e.*, the original beam has been broken up into two beams generally designated as the "extraordinary" or *E* beam and the "ordinary" or *O* beam (Fig. 1a). The *E* beam has all its transverse vibrations in or parallel to a plane of which the optic axis of the prism is a trace. The *O* beam will, in general, have its transverse vibrations in or parallel to a plane the trace of which makes a right angle with the optic axis. The two beams will not, in general, pass through the prism at the same speed and upon emergence the *O* beam will be retarded relative to the *E* beam. The amount of retardation is equal to the difference in the index of refraction along each of the two axes multiplied by the thickness of the prism. If *ie* is the index of refraction along the optic axis and *io* is the index along the axis at 90°, the retardation of the *O* beam relative to the *E* beam will be $(ie-io)t$.

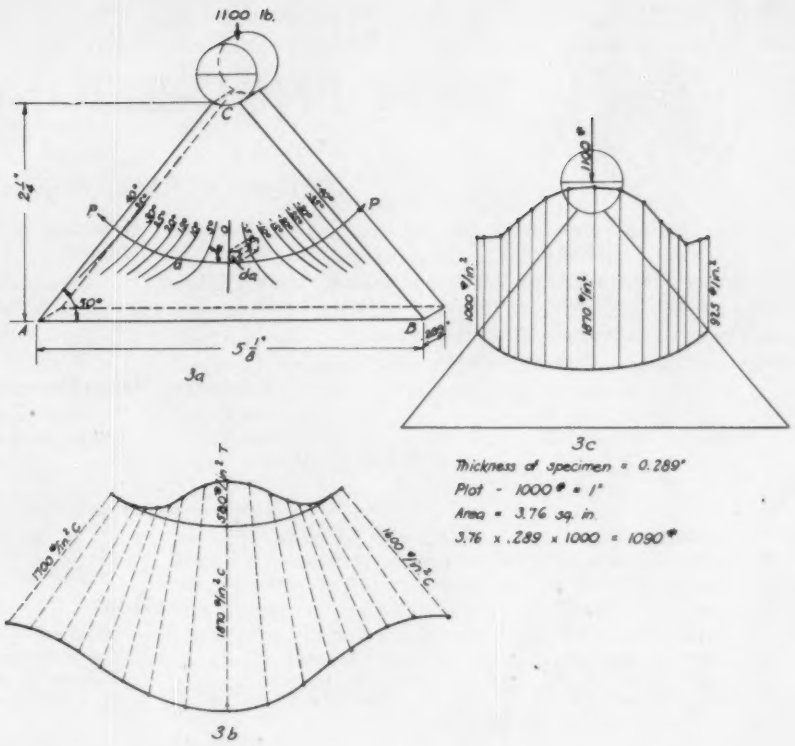
Temporary Double Refraction. Glass, celluloid, and bakelite are transparent materials which are not double refracting when unstressed. However, when a prism of one of these materials is subjected to plane stress it becomes double refracting and will have the same effects on light as prisms of quartz or calcite. The optic axis of such a prism, it has been found, is the trace of a plane normal to the principal plane upon which the greater tensile (or smaller compressive) principal stress is acting. It has been found that the index of refraction for each of the refractive axes is proportional to the intensity of the principal stress acting on the plane normal to that axis. Therefore, the retardation of the *O* beam relative to the *E* beam will be proportional to $(P-Q)t$, where *P* and *Q* are the principal stresses and *t* is the thickness of the prism.

Plane Polarized Light. The "Nicol" prism is a piece of calcite so cut that the *O* beam is bent to the edge of the prism where it is absorbed in a coat of black paint. The *E* beam passes through the prism. The light which emerges from the prism has all its vibrations in or parallel to the plane of which the optic axis is a trace. Such a beam of light is "plane polarized " (Fig. 2a).

Let a prism of bakelite stressed with two principal stresses *P* and *Q* be placed in a beam of plane polarized light of intensity *A* (Fig. 2b). Let α be the angle between the plane of polarization and the principal plane upon which the *P* stress is acting. The plane polarized beam will be refracted into two beams in the



The phenomenon of double refraction is the basis for photo-elastic analysis.



manner discussed under "Double Refraction." The intensity and retardation of the two component beams is as shown in Fig. 2b. It should be noted that as viewed from the source of light the O beam has been rotated clockwise by an angle a and the E beam has been rotated counterclockwise by an angle $(90°-a)$.

Let these two beams fall upon a second Nicol prism, called the analyzer, the optic axis of which is at right angles with the original plane of polarization (Fig. 2c). The O and E beams are each split by the analyzer into two components O_1 and O_2, and E_1 and E_2 respectively. The components O_1 and E_1 will vibrate in the plane at 90° to the optic axis and will be bent to the edge of the analyzer and absorbed.

The components O_2 and E_2 will be of equal intensity and will vibrate in the plane of the optic axis. The O_2 component will be rotated from the plane of the O beam through a clockwise angle of $(90°-a)$ which added to the rotation of the O beam at the stressed prism makes a total clockwise rotation of 90°. The E_2 component will have been rotated counterclockwise a total of 90°. The light vibrating in the plane of the optic axis consists then of two beams of equal intensity which are 180° apart in rotation. If the O beam had not been retarded relative to the E beam at the bakelite prism the O_2 and E_2 beams would neutralize each other. No light would pass the prism and the screen would appear black.

Let the original beam of light be white and let it be supposed that $(P-Q)t$ has such a magnitude that the O beam is retarded one-half a wave length of green light. It is evident that the green light will be brought into phase while all other wave lengths would be partially or completely out of phase. The screen would appear green. As $(P-Q)$ varies, the thickness of the prism remaining constant, the light on the screen would change from one color to another. If the state of stress was such that $P=Q$, the O beam would not be retarded relative to the E beam and the screen would appear black.

If the position of the plane of polarization is changed so that the angle becomes 45° and the optic axis of the analyzer is placed at 90° to the plane of polarization, the component beams O_2 and E_2 will have their maximum value. This will give the light on the screen its maximum brightness and the color produced by the interference of the O_2 and E_2 beams will be more sharply defined than for any other setting of the prism.

By stressing a prism of bakelite with a single principal stress such as simple tension, the value of $(P-Q)$ is equal to the applied stress. In this way it is possible to calibrate the colors which appear on the screen.

As was stated above, to determine the state of stress in a body it is necessary to know the magnitude and direction of each of the principal stresses acting at any point in the body. The value of $(P-Q)$ alone is not sufficient.

Direction of Principal Planes. Let the plane of polarization be changed so the angle a (Fig. 2a) becomes zero. There will be no E beam upon emergence of the light from the stressed prism. The entire beam of plane polarized light will pass through the specimen unchanged in direction or intensity. If the light now falls upon a second Nicol prism whose optic axis is 90° to the plane of polarization the entire beam will vibrate in the analyzer in a plane at 90° to its optic axis. The beam will be bent to the edge and absorbed, leaving the screen black.

It is evident, then, that a black screen indicates first, that the plane of polarization coincides with one of the principal planes; or second, the two principal stresses are equal in magnitude and sign. Which of these conditions exists can be determined by rotating both Nicol prisms through an angle of 45°. If the screen becomes colored the first setting was such that the plane of polarization coincided with one of the principal planes. If the screen remains black for all settings of the prisms the principal stresses are equal.

Application to a Simple Problem. A triangular block of bakelite (Fig. 3a) is subjected to a load of 1100 lbs. applied through a steel cylinder. The block is supported on a ground steel plate. The problem is to find the stress distribution on any section such as PP.

Let the stressed block be placed in a beam of plane polarized light so that the surface ABC is normal to the beam. Each tiny element of the body, such as $(da \times t)$ (Fig. 3a) becomes a double refracting prism. If the polarizing Nicol prism be adjusted so that its optic axis is vertical, and the analyzing prism so that its optic axis is horizontal, then all the elements in the stressed body at which the principal stresses are vertical and horizontal will appear black. Usually these elements will be connected and will appear on the screen as a black line. Such a line is known as a line of one direction of principal stress, or as an isoclinic line.

The prisms can now be turned through a succession of angles and for each setting the isoclinic lines can be traced on the screen. Such a set of lines are shown on Fig. 3a, marked 5°, 10°, etc.

Principal Stress Lines. At any point such as d in the body there are acting two principal stresses P and

(*Continued on page 60*)

The TECH ENGINEERING NEWS

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EDITORIALS

PROPHECY

PERHAPS one of the most difficult tasks in life is that of the prophet. Unless one predicts enough things to occur, so that at least a moderate percentage will come true, acceptance of the rôle is a great risk and may result in loss of reputation for good judgment; for, "Who shall bring us to see that which will be after us?"

Of one thing, however, we can be sure. It is that with such a start as science has obtained in the past century with the benefits obtained by the application of scientific principles, those whose span of life may be extended another fifty years under conditions we should call normal today, will witness great marvels, not the least of which will be the removal of fear of disease and disaster following thereon. Invention will not be halted and there are many unsolved problems in technical advancement still existing, the solutions of which will be sought and solved in time.

Much will of course depend on the existence with mankind of a beneficent and stable economic system, not necessarily one which forbids improvement and progress in the best sense.

This might include more rational economics guided by a higher statesmanship than that under which mankind has lived and suffered in the past. It would seem to be far more difficult to discover what is sound or unsound in the economics field where human conditions and emotions have to be reckoned with, than in the field of science and its applications, where principles are unchanged and unchangeable when first discovered, and where their applications must necessarily give rise to results which are predictable.

ELIHU THOMSON.

FRANKLIN DELANO ROOSEVELT

ON March 4, 1933, Franklin Delano Roosevelt assumed the presidency of the United States. That date marked more than a mere change of incumbents; it had a greater significance than the victory of one party over another or even of one system over another; on that day appeared the first signs of what from this close range seems to be an economic and political renaissance.

America was indeed in need of rebirth; the bustle and the hustle of the early fall of 1929, the frenzy and nervous energy of those feverish October days were the last fitful tossings of a dying patient; after that came despair, deeper and darker as time went on. Inactivity became torpor; torpor passed into petrification.

Washington aped the country. The government early made a few ineffectual attempts to remedy the situation, which were apathetically and discouragingly received. After a few more abortive measures, the Federal government sank back into coma. Even the election of Mr. Roosevelt in the fall of 1932 did little to shake governmental lethargy. The incoming president steadfastly refused to commit himself with definiteness to any programme, while Mr. Hoover inactively awaited the day when he could lay down the affairs of state, and the lame-duck Congress successfully avoided constructive legislation.

The inauguration of Mr. Roosevelt had a tonic effect on public confidence far surpassing that claimed for any patent-medicine panacea when applied to the ills of the human body. Official Washington sprang to life as messages began to pour out of the White House. In quick succession the President declared a banking holi-

day, placed an embargo on the export of gold, secured the passage of the emergency banking act. A legislative body scared into coöperation put through the economy bill, gave the President authority such as no other president has held in peace time. A seventy-word message to Congress resulted in the beer bill, hailed everywhere with new enthusiasm. Measures for unemployment and farm relief have followed.

Much of the President's success has been due to the lack of organized opposition. A Congress driven by bank shut-downs into a blind trust of Mr. Roosevelt's firm leadership and compelled by the overwhelming approval of its constituents to close coöperation with him, at first gave the President every aid. With the dying down of public clamor and the passage of some hasty, ill-considered legislation, Congress has given signs of a desire to debate and to reject. Mr. Roosevelt has shown himself a shrewd politician in delaying patronage distribution and in introducing the beer bill into Congress just in time to push through a slowly bogging-down administration measure. If by the exercise of these and other prerogatives of an Executive he can keep a Congress, which, after all, is strongly for him, on its toes and working hard, he will soon have fulfilled every campaign pledge.

IN MEMORIAM

INSTITUTE men the world over feel the tragedy of the Akron disaster and sympathize with the families of the four Technology graduates who went down with the airship. At the same time they experience a thrill of pride in the fact that their friends and classmates were members of a group exhibiting the courage and devotion to duty shown by the crew of the Akron.

Requiescant in pace.

CLASSROOM SARCASM

THE use of taunts to stir individuals to achievement may have had its place in previous decades. However, does such a system fit into modern educational plans? The rivalry between various courses has more than once led instructors to make sarcastic remarks to the students. Such remarks are usually made in a spirit of fun and accepted in that way. But when a class must face a daily dose of sarcasm directed not only toward courses, but toward individual students as well, the fun has ceased. An educator can make a subject likable by a decent understanding of his students. Why then must he taunt his students to such an extent that they harbor a dislike not only for the study but also for the instructor?

A TWO-EDGED SWORD

THAT modern systems of communication have made the world small is a fact so well appreciated that it is taken entirely for granted. Transatlantic broadcasts have lost their novelty. World-wide telephone service is no longer an expensive luxury. But this blasé acceptance of the power of modern invention need not prevent thoughtful citizens from realizing the significance of transatlantic radio in the expression of world opinion. The widespread feeling aroused by the Nazi persecution of the Jews in Germany is a case in point. A protest meeting, which had among its participants such men as Alfred E. Smith and William Green of the A. F. of L., was broadcast recently on the omnipresent international hook-up. What was said, therefore, traveled at the highest velocity known to science straight to the government for which it was intended, and we can be confident that official observers of that government were listening to every word that was said. What an improvement over the dry print of the newspaper reports! The emotional pattern of the protest, so important in conveying the real feeling of a people, was reproduced with all its original vivid coloring.

As powerful a force as modern communication is for the furtherance of world peace, engineers should realize its dangers. Like so many modern engineering triumphs world-wide radio is a two-edged sword. Used carefully it can add immeasurably to the solidity of the world community. But in the hands of selfish propagandists it becomes a powerful weapon for creating international friction and distrust. The use of the international hook-up is, therefore, a responsibility which the broadcasters must discharge with the greatest care.

ECONOMICS

ECONOMICS has been barber shop talk since the vague and remote period of Neanderthal Man, when the tribe hairdresser, while tying vicious-looking knots into the hair of some proud warrior, discussed such topics as the nuisance of predatory neighbors or the danger of a spring flood. Barbers have kept their traditional forum unchanged from then until now but they have been tricked; economics has become confusedly complicated. Even the apprehensive American barber can now cover only a few of the salient issues in the time it takes to cut one's hair.

What then? Shall we deprive man of his greatest gossip or educate him to talk more intelligently about the world? The former task would be monstrous, the latter much less difficult. Why not introduce the study of economic theory into primary schools, and make it a compulsory subject in secondary schools? By familiarizing men with the axioms and postulates of sound economic theory such shallow-minded conceptions as Technocracy would not succeed in duping the public; barber shops would wax more conservative and constructive.

Technology Review — H. Armstrong Roberts

ENGINEERING DIGEST

Condensation of outstanding articles in the trade and scientific journals, published by special permission

HAMMOCK ROOF

Electrical Engineering, *January, 1933*

RESEMBLING large steel hammocks, sheets of welded steel will constitute the roof of four huge grain elevators being built for the Port of New York Authority at Albany. The 140-foot strips of welded sheet steel, attached on one end to tall center ramps, on the other to small side ramps, are allowed to drape between these supports in a curve. By this process economy in construction is obtained as well as a decrease of seventy-five per cent in the cost of storage space.

Each section, 140 feet long and 50 inches wide, is assembled on the ground from several sheets of 12-gage mild steel. Each of the roofs is composed of seventy-five of these narrow sections, which weigh all together four hundred tons. Butt welds join together the smaller sheets, except for one joint in each section, which is lap welded to take care of any expansion or contraction caused by the butt weld.

Each section was hoisted into place, supported by two steel cables, and anchored by bolts to the center and side ramps. Alternate sections were erected first, leaving a gap of 46 inches, which would be covered later by intermediate sections. All sections were joined by continuous welds along each seam, the step-back method being used to dissipate heat and prevent distortion. Small expansion joints were welded in place over every tenth longitudinal seam. In all 12.3 miles of welds were required for the four roofs.

The welding was done by the "shielded arc" process, using 5/32 inch Fleetweld electrodes with a current of 150 amperes at 32 volts. With a total of eight operators, forty to fifty feet of welding could be done in an hour.

SYNTHETIC WEATHER FOR RAILROADS

Electrical Engineering, *February, 1933*

THE day of hot, stuffy train journeys in summer will soon be over. Air conditioning of railway cars, developed by W. C. Goodwin and Charles Kerr, Jr., a Massachusetts Institute of Technology graduate of '22, will provide adequate comfort for passengers. Tests conducted last summer proved that a power generator and a cooling unit could be installed within the space and weight limitations of railway service. The source of power is a direct current generator which is geared to the axle of the car. The generator required a fifteen kilowatt capacity to furnish current both for the refrigerating unit and the lights of the car, while the present type of flat belt drive between axle and generator provided only five kilowatts. A flexible gear drive, capable of withstanding the bumping stresses produced in the coupling of cars was therefore designed. Batteries are used to furnish current during stops at stations.

Regulation of the voltage of this generator presented some interesting electrical problems. When the car starts the power is supplied by the batteries and, at the proper speed, the generator must be cut in and kept at a constant voltage even when the velocity of the car increases. A regulator, which cuts out one-half the field of the generator as the train accelerates, is used for this purpose.

The refrigerating unit employs an easily compressed gas, Freon, as a refrigerant. Because it would be difficult to obtain sufficient water along a railway, the condenser of the unit had to be air-cooled. A special fan of aluminum alloy was used to supply the air required and the cooling surface of the condenser was made as large as possible. Throughout the whole study, the stringent clearance regulations for railway cars handicapped the designers.

Electrical Engineering

Hoisting a strip of steel roofing into place.

STREAMLINING

Machine Design, *March, 1933*

STREAMLINING of private automobiles has finally arrived. The latest automobile designs indicate that manufacturers are applying the principles that Campbell and Segrave used on their racing cars and are rewarded with increased speed, efficiency, and beauty of design, all of which may tend to increase sales.

Pierce-Arrow has won the attention of the public with the clean and graceful appearance of its Silver Arrow (see illustration on page 43), which is capable of 115 miles an hour and has a cruising speed of eighty miles an hour. The streamlines converge smoothly at the rear of the car and the headlights are blended into the contour of the fenders. The spare tire is carried in a shrouded compartment behind the front wheel, preventing broken lines which would disrupt the plan. A sloping windshield sweeps gracefully to the metal roof, giving an easy rotund profile, which might remind one of a yacht.

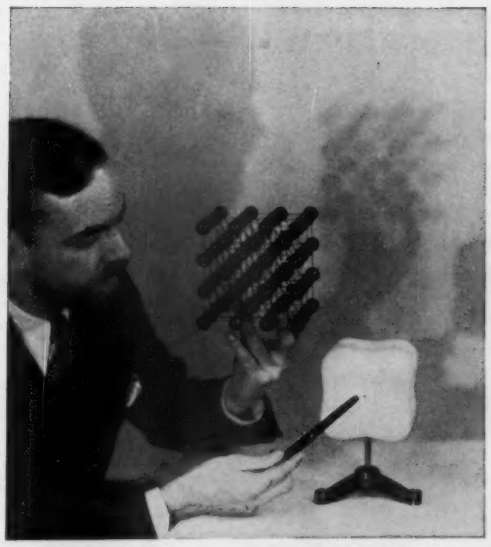
The characteristics which mark a streamlined vehicle are objectives in design that are finding wider acceptance among automobile manufacturers.

ATOM: OSCILLATING MAGNET

Westinghouse Technical Press Service

MAGNETIZED atoms of iron are now believed to be very much alive and active. Dr. Francis Bitter, research physicist for Westinghouse, offered evidence in a recent address before the American Physical Society that the direction of an atom's magnetic force constantly oscillates in the manner of an automobile's windshield wiper. Thus he tosses into the scientific scrap heap the fifty-year-old theory that the directional force of magnetized atoms is dormant.

He rejects the former hypothesis that atoms in magnetized iron obey static laws, such as would apply



Model of a crystal of magnetized iron; each ball represents an atom.

to structures not in motion, and claims that they are governed by the laws of dynamics.

Dr. Bitter's observation of the fact that the magnetization of an iron bar changes if the bar is strained in any way led to his doubt of the static theory, according to which distortion of the metal's crystal structure should not affect the bar's magnetization. By assuming directional oscillations of the atom's force and by applying dynamic laws, he was able to explain many magnetic phenomena and to predict the magnetic properties of an atom under all conditions of field.

To illustrate his theory, Dr. Bitter exhibited several models. A crystal of iron was represented by a large cube made up of many small wooden balls, each representing one atom. The magnetic property of the crystal was illustrated by plaster casts, which changed their shape with the magnetic field. When a crystal of iron was not subject to any external magnetic influence, its ease of magnetization was represented by a plaster cube with rounded corners and a depression in each face. As the applied field changed, the plastic mass changed its shape, the depressions also altering in shape, depth, and position.

Many scientists agree that Bitter's development opens up a new field of exploration of the properties of solids. His findings may profoundly affect the design of electrical equipment of magnetic character, and may even extend to metals in everyday use.

UNIVERSAL PROVIDER

The Scientific Monthly, *February 1933*

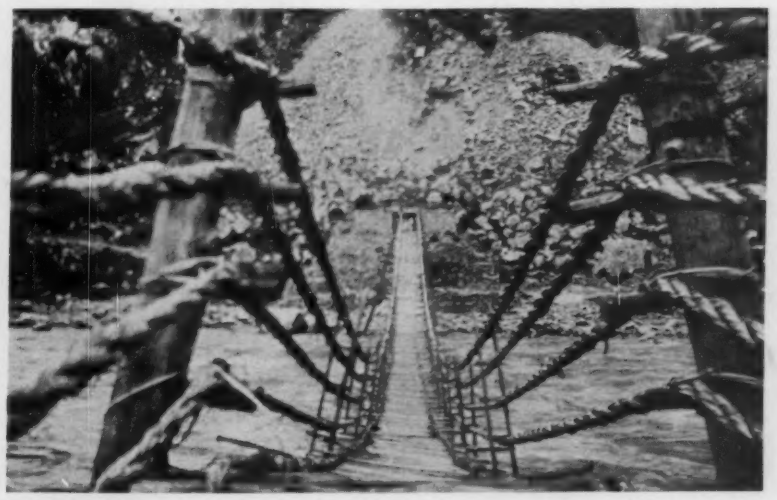
CONTESTING the statement that the coconut is the most useful plant in the world, a professor at a Shanghai university has discovered so many varied uses of bamboo in the Orient that he has termed it "the universal provider." His survey has included the uses of the tree-grass not only in China and Japan, but also in Formosa, Siam, India, Sumatra, the West Indies, Central and South America, and Madagascar.

The average Oriental carries a bamboo bushel basket to market on bamboo poles, wears a bamboo hat, smokes a bamboo pipe, writes (if he is literate) with a bamboo pen on paper made of bamboo pulp, stirs up the sultry summer air with a bamboo fan, buys for his children bamboo kites, and has creamed sliced bamboo shoots for lunch. The more wealthy may live in an apartment house built within a bamboo scaffolding and covered with bamboo strips, and keep their cars in garages of bamboo.

Marco Polo, in his "Travels," tells of observing the Chinese tow their ships against the powerful current of the swollen Yangtse River with ropes made of split, twisted bamboo fibers. Bamboo is still used this way and engineers have calculated that such rope will withstand a stress of 20,000 pounds to the square inch. Robert Fortune wrote of a process by which paper was manufactured with bamboo pulp saturated with lime.

Over the Min River in China is the best known of the many bamboo suspension bridges in the Orient. Held up by cables of twisted bamboo, which run over seven supports, the bridge measures 250 yards in length and nine feet in width. In the Las Pinas church on the Philippine Islands is the world's only bamboo pipe organ, which contains 950 tubes. Flutes and xylophones are also made of this material.

One thousand forty-eight practical and five hundred ornamental uses of bamboo are known. The plant will grow three feet a day and its structure is mechanically perfect.



Bamboo suspension bridge across an Oriental river.

The Scientific Monthly

NATURE DEFEATED

SWITZERLAND advanced another step in the electrification of the country when the Oberhasli hydroelectric development in the Bernese Oberland was turned over to regular operation on October 1, 1932. The problems encountered due to the nature of the terrain were varied and interesting. About 95 per cent of the total precipitation flow takes place during the six summer months, and only 5 per cent during the six winter months. To maintain a constant supply of water for the turbines two large artificial lakes were created.

Due to the large number of avalanches coming down regularly every winter in the neighborhood of the generating station the power is carried by underground cables instead of the usual high tension overhead lines. Perhaps the most unique feature of the entire development is the fact that in the tunnel that bears the underground cables a small electric car is operated. This car is the only means of reaching the valley from the station during the winter.

RESEARCH IN REVIEW

OPEN HOUSE DAY
May 6, 1933

Plans for the Tenth Annual Open House, May 6, are now well under way and give promise of an Open House superior to any previous one. All preparations are under the direct supervision of the Combined Professional Societies, which originated Open House in 1922.

The Physics Department will have a particularly complete exhibit, since the new George Eastman Laboratory will be dedicated several days before Open House. For this dedication the department is planning to have all research projects on display for the many visiting scientists that are expected. The new Spectroscopy Laboratory with its light, heat, and shock-insulated rooms, will have a number of spectrographs and spectacular atomic excitation sources in operation.

To this series of exhibits it is planned to add a number of more spectacular ones in order to make the Open House display even more fascinating. Among these exhibits there will probably be a model of Van de Graaff's high voltage machine, some cosmic ray apparatus, hydraulic apparatus to study cavitation and also a large model being used to study tides in the Cape Cod Canal.

The Tech

Prize-winning poster, announcing Open House Day; drawn by John W. Mihnos '33, of Course IV.

As in past years, Course I will have a model railroad working continuously throughout the day. It will be as automatic as possible; there will be automatic block systems whereby only one train can be in a block at one time, self-operated switches which prevent collisions at crossings, and which will also sidetrack a freight train to allow a fast express to pass.

In the Chemistry Department an effort is being made to secure Room 10–250 so that freshmen may present lectures and demonstrations on the subject of chemistry. Students will be working in all the laboratories, and a complete rubber plant will be in action under the direction of upperclassmen.

Open House would not be complete without running the old triple expansion engine in the Steam Laboratory. As a result, students in the Mechanical Engineering Department have decided to run a four-hour comparison test between it and the adjacent steady flow engine, both being rated at the same horsepower. In the machine tool laboratory one will be able to obtain and see made bright metal souvenirs. The photo-elasticity equipment in the testing materials laboratory will also be on demonstration to show how it is used to detect stresses in materials by means of light beams.

Extracurricular activities will be represented in various ways throughout the day, too. There will be exhibitions in boxing, fencing, and wrestling. The track team will meet the University of Maine. The annual Technique rush will be held on Walker field and the new 1933 *Technique* will be distributed. The *Voo Doo*, *The Tech*, and the TECH ENGINEERING NEWS are all planning special issues for the day, while the Combined Musical Clubs, the Dramashop, and the Tech Show are planning skits for the crowd which will number as much if not more than the one at the last Open House, when about thirty thousand attended.

COURSE III
Mining and Metallurgy

One of the fundamental problems of Physical Metallurgy is a more complete knowledge of the mechanism of the diffusion of one metal into another when both are solid. The fact that such diffusion takes place with many metals, as of lead into gold, has been known for years, but little information as to why and how it occurs is available. The problem under investigation is a study of the diffusion of chromium into iron, a question of theoretical importance and also of possible practical interest in connection with the behavior of stainless steels. In attacking this problem, a specimen of pure iron packed in pure chromium powder has been heated in a vacuum furnace at a temperature of 1200° C. for periods of several days. That marked diffusion has occurred is shown clearly in enlarged photographs of a polished section. Such photographs show also the columnar character of the alloy in the diffusion zone.

The specimen will be studied in detail at high magnifications to determine the metallographic characteristics of the diffused material. At the same time, precision methods of x-ray analysis are in progress to determine changes in the lattice parameter at successive small intervals in the diffusion zone.

COURSE XII
Geology

An interesting new development of the last decade in the technique of geological exploration has been the introduction of geophysical prospecting methods. A former serious handicap in the use of the electrical resistivity method has recently been overcome. Dr. Louis B. Slichter, professor of geophysics at the Institute, reports that the use of Dean Vannevar Bush's mechanical analyzer has been very useful in interpreting the field data.

AUTOMOBILE DESIGN

(*Continued from page 44*)

suitable speed, so that the advantages of high speed with moderate power in a streamlined car do not seem adapted to American desires at the present time.

In this country any innovation in motor car construction is met with suspicion and sometimes derision. To be acceptable to the public a motor car must be more or less like other cars. In Europe the situation is different. Engineers are allowed to create and exhibit novel ideas, and the public is eager to see these new creations and comment upon them. There are contests in Europe where stock cars can compete with each other. The result is that Europe has in the past developed many ideas that have eventually met with favor in this country. There is no reason to believe that they will not continue to do so in the future.

In the past few years we have seen engine power increase greatly. Engines are being operated at higher speeds and with higher compression ratios. The end is not yet in sight. With what power the driving public will be satisfied is a question that can be answered only by time. It seems that the poppet-valve type of engine will continue in favor due to its high state of development and its comparative cheapness. The sleeve-valve engines continue their successful progress in Europe, but the expense of building them is too great to make them a commercial success in this country. The two-stroke-cycle engine is being developed experimentally and may return to favor, but at present the chance seems remote. The light Diesel engine has been receiving much attention of late, and it is being used in some busses and trucks with varying success. Its high initial cost to some extent offsets its saving in fuel; also, no definite maintenance figures are available. An interesting development is being conducted where existing engines are being modified to start and run on fuel oil using a carburetor and ignition system. If this meets with success it will eliminate the fire hazard of gasoline and permit the use of Diesel type fuels in an engine of moderate cost. None of the so-called internal combustion turbines or rotary types of engines have threatened the present type of engine for use in automobiles.

To predict what the future may bring is hazardous. Performance will increase. Automatic, infinitely variable gear ratio transmissions will probably be developed. Riding, road-holding ability, and directional stability will be improved. Driving operations will be simplified and made easier. If the present lowness of cars is continued, sloping engine-hoods may return. These will give better visibility, especially in traffic. Body lines will become smoother, and fewer projections will be in evidence. Spare tires will be carried in the body. The small "baby" type of car probably will not meet with public approval. The American buying public wants a big package for the money with plenty of style and lots of action.

"WHAT TIME IS IT?"

(*Continued from page 45*)

The time that the observatories keep, however, is not the same as the time kept by the rest of the world. The astronomer's year consists of 366.24 sidereal days, while the ordinary year contains 365.24 solar days. This difference arises from the fact that, since the sun is always moving eastward, the earth, in completing one revolution about its orbit, makes one more rotation in respect to the fixed stars than in respect to the sun. Since the time that the observatories give to the world must be solar time, the standard solar clock is corrected regularly from the standard sidereal clocks, with allowance being made, of course, for the difference in the units.

Time signals are sent out six times daily from the observatory during the five minutes preceding the hours of 7 p.m., 10 p.m., midnight, 3 a.m., noon, and 4 p.m., Eastern Standard Time, and are broadcast from four radio stations at fourteen different frequencies, so that they can be received all over the world.

Telegraph wires convey impulses once daily from the Naval Observatory to every municipality in the United States possessing a telegraph office. At five minutes to twelve, noon, the Western Union opens a nationwide network of telegraph lines. Over this an electric relay on the escapement wheel of the standard clock closes a circuit at the beginning of each second causing a sounder to click in every telegraph office.

These clicks, omitted on the twenty-ninth second of each minute, and also from the fifty-sixth to the fifty-ninth second, inclusive, are used to correct master clocks and sub-master clocks in telegraph offices; the latter instruments send out correction impulses on the hour to the familiar clocks marked "Naval Observatory Time Hourly by Western Union." Coils in these are magnetized and their minute and second hands are forced to point to "60" once each hour. This same impulse is the source of the hourly 'bloop" heard over the radio, by which many of us set our clocks. Western Union also has a jewelers' time service. Thus, in several ways, the hands of all our clocks and watches are controlled by those of the standards in Washington.

"Mother of pearl" stratosphere clouds.

Science News Letter

MANUFACTURE OF BEER

(*Continued from page 46*)

occur in quantity, cause a good deal of trouble and spoil the beer.

One variety of yeast is called "top fermenting," and is used in the fermentation of ales; another called "bottom fermenting yeast" is used in lagers. The former stays on top of the fermenting wort, the latter sinks to the bottom. After fermenting, the beer is usually stored, and allowed to age under carbon dioxide pressure for one to two months. During this period some secondary fermentation occurs, certain matter precipitates, the beer is charged with carbon dioxide, and, in general, the beer becomes "conditioned."

The Brewery. The brewery provides for the receiving of materials, the manufacture of the beer and its preparation for distribution. Thus there is a storage section for malt and hops, a brew-house, fermenting and storage rooms, a bottling shop, a barreling plant and shipping facilities. Its size varies from a yearly production of 30,000 barrels (of 31 gallons each) in a small plant to 500,000 in a large brewery, with about 200,000 barrels per year as a usual size.

The malt is usually received in carloads, trucked to the brewery, and transferred by conveyors to storage bins. It then travels by conveyors to a malt crusher, thence to a weighing hopper. For a medium sized brew, say 200 barrels, about 15,000 pounds of malt are used.

The malt is now extracted in a "mash tub." This is a steel tank about fourteen feet in diameter and seven feet deep, with a revolving rake for stirring and a slotted false bottom for filtering. Here the malt is mixed with hot water and "mashed" for about two hours, then the solution is drained off, and the malt sprayed with more hot water until very little soluble matter remains in the spent grains.

The extract then runs to the "copper," a pear-shaped jacketted copper kettle about 11 feet in diameter and 12 feet deep with a dome cover and vapor exhaust pipe. Here, after bringing the contents to a boil, hops are added to the amount of one-half to three pounds per barrel. After boiling for approximately two hours this solution is run through a hop strainer or, at times, a hop jack, and from there it goes to a cooler. This cooler is usually a series of horizontal thinned copper tubes where the hot wort runs down the outside being thus cooled and aerated. This type is called a Baudelot Cooler, but in some breweries a closed double pipe cooler is used.

The equipment up to this point is in the brew house; after that come the fermenting rooms where the wort is pitched with yeast, using about one pound per barrel of wort and allowed to ferment for from one to two weeks. This is usually done in glass-lined steel tanks, but wooden fermenters are also used. After fermentation the beer is stored in cooled rooms for from one to two months to allow a proper aging. Due to the long time required for the process this section of the brewery is always large.

After the beer has aged properly it is either put in barrels, *i.e.*, "racked," or bottled. The bottling shop has modern, high-speed automatic equipment — and is the only part of the brewery which has. The machinery in the bottling room consists of bottle washers, bottle fillers, crowners, pasteurizers, and labellers.

Some idea of the future of the industry may be obtained by considering the following statistics. Before prohibition there were from forty to sixty million barrels of beer produced each year in the United States by about 1200 breweries. Just prior to the present time there were about 200 breweries producing near beer. Most of the former brewery buildings still stand vacant, but in the majority of cases the equipment has been removed. It is easily seen that probably a fair amount of new brewery equipment will be required and that shortly a large amount of new bottling machinery will be needed as modern bottling equipment is so far ahead of old-fashioned machinery that it will displace obsolete equipment at an early date. Possibly the only reason that equipment will not be bought quickly is the lack of capital available for investment in brewery work. Many brewery properties are now being organized with the hope of selling stock, thus allowing the public to participate in the business. However, the public does not seem to be too interested in investing, or possibly has already lost all its money.

Since Prohibition industrial fermentation has advanced far due to the researches directed at the production of lacquer solvents and ethyl alcohol. These will be applied very slowly in brewery practice, but nevertheless they will be applied in time. It seems that attention will be directed towards elimination of the batch operations of the brew house and possibly of fermentation. Faster methods will be desired, and indeed it is claimed that the Nathan process now used in Europe will produce a lager beer of the highest quality in ten days' time as against the usual two or three months.

Just what economic consequences the resurrection of the beer industry will have, remains to be seen. Many men will be put to work in breweries and in factories where barrels, bottles and other equipment are manufactured, and the unemployment situation will be eased somewhat thereby. Much American money which now flows into Canada and Mexico will remain within the borders of the United States when Americans can buy beer at home.

On the other hand, money spent on beer by the buying public will, to some extent at least, necessitate smaller expenditures for other goods, soft drinks in particular. How industry as a whole will be affected by the return of beer is a question that time alone can answer.

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STAINED GLASS WINDOWS

(*Continued from page 49*)

these wooden bars, and, beginning in the corner, a piece of glass is fitted into the grooves of both leads. A strip of smaller lead is now cut long enough to cover the opposite sides of the glass and it is bent into shape, inserting the glass into one groove. Into the free groove of this lead the next piece of glass is inserted, and so on, until all the pieces are leaded. Then all the joints are soldered on both sides.

The window is now one piece, but it must be cemented in order to make it rigid and make it thoroughly watertight. It is laid on a bench and completely covered with a waterproofing cement, composed of portland cement, whiting, lampblack, boiled linseed oil, turpentine, and a patent drier. With a stiff brush the cement is forced under the leads on both sides of the window, and after cleaning off the glass with sawdust, the cement is allowed to dry and harden.

To prevent the window from bulging and sagging, horizontal bars are fastened into the window sash at intervals, and to these bars the window is joined by small pieces of copper wire soldered to the lead at joints and twisted around the bars. Often these bars are bent to conform with the design of the window, and in some types of windows, the bars are a governing factor in the design, where these heavy black lines give contrast to the color and strengthen the design. In order to give the window additional strength, it is made in sections not more than three feet high. Heavy Tee bars are fastened into the grooves, and each section (except, of course, the bottom one) is supported by one of these horizontal Tees. These small sections also facilitate the shipping of large windows.

In installing a window the glass worker is frequently confronted with difficulties. When a window is to be set in stone, the grooves are sometimes made too shallow, and the worker finds it necessary to take the window apart at various places in order to insert the glass into the grooves, later resoldering and recementing the glass. Whenever the stonework is intricate in design and construction, this cutting apart cannot be avoided. However, if the grooves are made deeper on one side than on the other, the setting will be made easier, for after inserting the glass into the deep groove, it can be pulled back into the opposite groove without any great difficulty. A wide groove is also helpful to the setter. A stop bead is used to hold glass in wooden sash, while small metal clips are screwed into metal casements to make the glass secure.

FROM GRIT TO GRINDSTONE

(*Continued from page 48*)

ing firing and also helps to maintain an even temperature distribution throughout the different points of the wheel. The sagger prevents the furnace gases from coming into direct contact with the abrasive articles. The accompanying photograph shows the saggers being piled one on top of the other during the loading of the kiln. The kiln is usually the "beehive" type of periodic kiln similar to those used in the large potteries, but some wheels are fired in continuous tunnel kilns.

After removing from the kiln, the next operation is to shape the wheel accurately so that it will run true in service. The first operation is to cut both faces of the wheel flat and parallel to one another. This is done on a large lathe, and the truing tool is not usually a diamond point, but a rotating hardened steel cone, whose action is really a prying rather than a cutting one. The depth of cut and the quality of finish left by this steel cone is almost unbelievable. A diamond is used on the smaller wheels and almost always on the wheels made with the tougher bonds.

When the sides have been machined flat and parallel, a lead bushing is cast in the center of the wheel. The wheel is then put on an arbor and the periphery is trued. After this operation it is graded for hardness. This is a hand operation and consists of gouging out a small hole on one face of a wheel with an instrument not unlike an ordinary screw driver. The operator who is responsible for the grading of the wheel determines what the hardness is by estimating the work required to wrench a few grains from the surface of the wheel, and stamps the grade letter on the wheel.

The wheel is nearly complete now, and it only remains to balance it and test it for safety. Wheels over twelve inches in diameter are balanced and all wheels of more than six inches diameter are tested for safety. The balancing is done by making a small undercut hole near the center of the wheel and filling it with lead, the result being very similar to a filling made by a dentist.

The testing for speed consists of placing the wheels on an arbor and running them at a speed which is well above the recommended service speed.

The present day excellence of grinding wheels is due largely to the time and effort spent in the laboratories of the manufacturers to improve their product. Inspection and control of the raw materials, inspection of the fabricated articles, control of grain size and shape, and the careful study of the bonding action have all contributed to the same end. The microscope has been very useful in the study and development of abrasives, both in the abrasive grains themselves and in the finished articles. For this work the polarizing or petrographic microscope is of great value in determining crystal formations in the abrasive grain, or for determining slag or impurities in them. It is also of help in the detection of impurities in the ceramic raw materials which go to make up the bond, and it is equally important in the study of the degree of vitrification of the bond.

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PHOTO-ELASTICITY

(*Continued from page 51*)

Q. The P stress acts normal to a plane which is inclined to the vertical by an angle indicated by the isoclinic line at the point. The Q stress acts normal to a plane inclined by an equal angle with the horizontal.

As successive points to the left or right of d are considered the direction of the principal stress P changes continuously in such a manner that the line PP is in the direction of the stress P at any point in the line. Such a line is known as a principal stress line.

Separate Values of the Principal Stresses. Consider a small prism such as $(da \times t)$ (Fig. 3a). It must be in equilibrium under the stresses acting on it. The general differential equation for equilibrium of such a particle is:

$$\frac{P-Q}{r}+\frac{dP}{ds}=0$$

where r is the radius of curvature of the line PP at the point and ds is the length of PP bounding one side of a particle such as $(da \times t)$.

The inclined edges of the specimen are unloaded, so that at the edge the stress in the direction of the PP line is 0. With these conditions it is possible to determine the separate values of P and Q at any point on the PP line by means of graphical integration. The equation used for this purpose takes the general form:

$$P_1=P_0-\left[\frac{(P-Q)_0\cot\psi_0+(P-Q)_1\cot\psi_1}{2}\right]\Delta\phi$$

where ψ is the angle at any point through which the principal stress line must be rotated counterclockwise to fall upon the isoclinic line, and $\Delta\phi$ is the change in direction of the principal stress between points 0 and 1. For the problem:

$$P_{35}=P_{40}-\left[\frac{(P-Q)_{40}\cot\psi_{40}+(P-Q)_{35}\cot\psi_{35}}{2}\right]\times.0873$$

where P_{35} is the value of the P stress at the point where the PP line intersects the 35° isoclinic. P_{40} is the value of the P stress at the edge. For this problem P_{40} is equal to zero.

$(P-Q)_{40}$ is the value of $(P-Q)$ at the edge as determined by the color of the point on the screen as mentioned above.

ψ_{40} is the counterclockwise angle between the line PP and the isoclinic line at the edge. For this problem ψ_{40} is equal to 90°. $(P-Q)_{35}$ and ψ_{35} are similar values for the point where the PP line intersects the 35° isoclinic line. The value .0873 is the change in direction of the principal stresses between the edge and the 35° isoclinic line expressed in radians. By successive steps from the point where the PP line intersects one isoclinic to the point at which it intersects the next the value of the P stress can be determined for each point on the line.

The value of the Q stress at any point will be the algebraic difference between $(P-Q)$ and P at the point.

Having the magnitude and direction of each of the principal stresses at a point the state of stress is determined. In Fig. 3b the values of the principal stresses for each point at which the line PP intersects an isoclinic are plotted. The Q stress at each point is plotted in the direction of its line of action; the P stress is plotted normal to its line of action.

Accuracy. The resultant upward force on any section PP of the model must be equal and opposite to the applied load. The accuracy of the solution for the principal stresses can be determined by use of this fact.

The sum of all the vertical components of the principal stresses multiplied by the area over which they are acting will be the resulting vertical force on the area.

The sum of vertical components of the stresses P and Q is plotted (Fig. 3c) to the scale of 1,000 lbs. per square inch. The area in square inches of the stress diagram multiplied by 1,000 t will be the resultant force on the section. This value is 1,090 lbs. as shown (Fig. 3c).

Not all problems on which the method is of use can be checked with such a high degree of accuracy. In many problems the isoclinic lines are vague and difficult to trace. In other problems the change in direction of the principal stresses is large in very small distances and the graphical integration becomes inaccurate. In such cases the method will give results that are more qualitative than quantitative and serve only to show the trend of stress distribution. At any rate photo-elastic analysis can often be successfully employed for the determination of stress distribution in transparent materials under circumstances which would render calculation by ordinary means impracticable or utterly impossible.

ERRATUM

THE TECH ENGINEERING NEWS wishes to correct an error which appeared in the March issue in the article "Oxygen: Friend and Foe." On page 38, lines 25 and 26, second column, "nitrogen" should be "ammonia."

That's what you'll say about Jimmie McHale's band playing nightly at THE CASCADES. And to add to your enjoyment there's Lou Walters' Revue with twenty-five lovely girls, and United Hotels food at special thrift prices! Call "Charlie" at Hancock 1400, for a reservation.

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G-E *Campus News*

COUNTING COSMIC RAYS

We hear a lot about cosmic rays, but know little about them. Some believe the rays are the birth cries of new matter, photons, which are like light rays. Others believe they're electrons, the death rattle of matter as it radiates itself away. But whatever the rays are, they come to us from every direction, night and day.

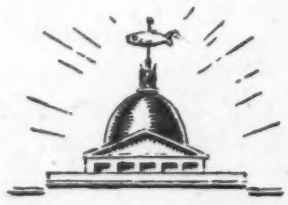
One of our engineers, Chester Rice, a '10 grad of Harvard, didn't think cosmic rays were so mysterious. He even perfected a device to count them. Imagine — counting cosmic rays! He counts them with a nickel cylinder detector that is suspended in a low-pressure tube. It's shielded by a housing of lead, 4 in. thick, to keep out the effects of radioactive material. The rays, passing into the cylinder, initiate corona discharges, which are fed into an amplifier, then through a radio loudspeaker. The rays can be heard as distinct clicks. The small cylinder has a count of eight rays per minute.

DNEPROSTROY

On October 10th last, the largest masonry dam ever built was dedicated in Russia. It's part of the tremendous Dneprostroy hydroelectric development.

There, Charles Thomson, who completed his engineering course in '13 at the South African School of Mines, Johannesburg, Transvaal, was honored by the U.S.S.R. He received the Order of the Red Banner of Labor for his skill. His had been the job of erecting all the electric apparatus. And some job it was!

As a construction engineer for General Electric, he spent 18 months in Russia. He put into operation the nine enormous 77,500-kv-a. generators, five of which were built by G.E. They're the largest water-wheel generators ever built. Incidentally, it was some achievement, considering the enormous weights, to ship the G-E generators and transformers nearly 6000 miles—and then to put them into operation successfully. Even engineering veterans were astonished.



MEET THE PHANOTRONS

Boston, proud guardian of the Beans and the Cods, has been harboring another celebrated family, lately. The name is Phanotron; present condition—that of lusty infancy; job—rectifying alternating current.

Housed in the Salem Street substation of the Edison Electric Illuminating Company in downtown Boston, this equipment is changing alternating current at 13,800 volts, 3-phase, 60 cycles, into direct current at 238 volts. Listed advantages: no moving parts, silent operation, high efficiency, economy in floor space. Six tubes, with a combined rating of 600 amperes, are employed. They are an outgrowth of the vacuum tube used in radio sets but have a current capacity 100,000 times greater.

The Phanotron rectifier, a highly desirable neighbor, comes from good old G-E stock, incubated in the Research Laboratory in Schenectady. Incidentally, Harry Steiner, a University of Kansas grad of '26, is largely responsible for its engineering and design development.

HELLO, WATERWORKS

Two pumping stations which supply the Baltimore water system have no personal attendants, but they are able to give a complete report of conditions existing at the plant when called on the telephone. If you know the telephone number (and the code in which the station elects to talk back), you have only to dial the station. The G-E audible indicating equipment in the station signals how well the pumping equipment is operating, what the water level is, the pressure, etc. It gives prompt, complete, and—if you please—courteous service. The public telephone system is used, but conventional house-to-house conversations in and around Baltimore are in no way affected. Operating officials delight in demonstrating the equipment to the uninitiated, letting them listen as the pumping station makes its report. "Amazing" is the now familiar remark.

Arthur Johnston, a '25 grad of Oregon State College, is largely responsible for this development. He also did much to develop telemetering and the electric scoreboard.

95-987DH
GENERAL ELECTRIC